

## ASSESSMENT OF SOME PHYSIOCHEMICAL PARAMETERS IN SACHET WATER PRODUCED IN ITU, AKWA IBOM STATE, NIGERIA

E. O. Etim, E. I. Uwah and E. A. Moses, K. R. Okokon

Department of Chemistry, Faculty of Science, University of Uyo, P.M.B. 1017, Uyo, Akwa Ibom State, Nigeria

### ABSTRACT

Physical, chemical and bacteriological parameters of sachet water produced in Itu, Akwa Ibom State were assessed to ascertain contaminant levels and compliance with standards set by regulatory bodies. Samples were collected from three different brands of sachet water factories in the area and coded as SW<sub>1</sub>, SW<sub>2</sub> and SW<sub>3</sub>. Standard procedures for water analyses were used for the assessment of parameters. The results showed that concentration of Pb in SW<sub>1</sub> was as low as < 0.001 mg/l. This was below the standard limit of 0.01 mg/l Pb in drinking water set by both WHO and National Agency for Food, Drugs Administration and Control (NAFDAC). Pb levels in SW<sub>2</sub> and SW<sub>3</sub> were 0.16±0.02 and 0.30±0.01 mg/l, respectively. The concentrations of Cu, Fe, Ni, some anions and physicochemical parameters in all the samples were either below or within the standard limits for drinking water set by WHO and NAFDAC except for PO<sub>4</sub><sup>3-</sup>, which values of 71.00±0.02, 66.50±0.01 and 66.50±0.00 mg/l in SW<sub>1</sub>, SW<sub>2</sub> and SW<sub>3</sub> respectively, were slightly higher than the standard limit of 50 mg/l PO<sub>4</sub><sup>3-</sup> for drinking water, set by both WHO and NAFDAC. In addition, the results revealed good water quality in terms of bacteriological evaluation as no trace of *coliform* or bacterial count was recorded in any of the brands. Consumption of the three brands of the sachet water may not pose health hazards at the time of the study.

**KEYWORDS:** Assessment, Physiochemical parameters, sachet water, Itu, standard limits

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Corresponding Author: [uwahemmai@yahoo.com](mailto:uwahemmai@yahoo.com)

### INTRODUCTION

Good quality water is odourless, colourless, tasteless, and free from any form of pollution (Ezeugwuenne et al., 2009). Water quality is determined by its physical, chemical, and microbiological properties. Every living being need water to survive. In fact, water of good drinking quality is of basic importance to human physiology and man's continued existence depends very much on its availability (Akuagbazie and Onweluzo, 2010). An average human (53-63 kg, body weight), requires about three litres of water daily to keep him healthy. Indeed water is regarded as one of the most indispensable substance. Like air, it is most abundant. However, despite its abundance, good quality drinking water is not readily available to man. In fact, safe and potable water supplies in urban and rural areas in Nigeria are still inadequate in spite of five decades of independence and efforts from various governments (Ajayi et al., 2008). The standard industrialized world model for the delivery of safe drinking water and sanitation technology is, however not affordable in vast developing nations (Dada, 2009). Consequently, given the renewed global commitments toward the Millennium Development Goals (MDGs) marked for 2015, the importance and contributions of healthy sourced low-cost alternative drinking water scheme for sustainable access in rural and urban settings of developing nations cannot be overemphasized. One of such local interventions is in Nigeria where public drinking water is sold in polythene sachets (SON, 2000).

Sachet water is readily available and affordable, but there are concerns about their purity. The integrity and hygienic conditions from where such sachet water is produced have been questioned (CAMON, 2007). Apart from environmental contaminants which include heavy metals, anions, microbes and others, contamination from



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improper handling by vendors poses threat to the health of ignorant consumers. Studies have identified handling as the source of infection in food and water-borne diseases in several countries (Dada, 2009). The National Agency for Food, Drugs Administration and Control (NAFDAC) is mandated to enforce compliance with internationally defined drinking water guidelines, but regulation of the packaged water industry aimed at good quality assurance has remained a challenge to the Agency. To control this menace of contaminated sachet water, NAFDAC declared a possible gradual nationwide ban on sachet water to allow their manufacturers to make a change to bottle packaging (CAMON, 2007). Successful implementation of this ban remains far from reality as sachet water market is witnessing remarkable growth, especially, among the poor and middle social class (NAFDAC, 2001).

Previous studies on sachet water phenomenon in Nigeria have shown that factors responsible for its contamination ranged from sharp practices, poor hygiene of vendors, polluted environments to non adherence to WHO/NAFDAC regulations. Mohammed et al (2010) carried out physical analysis such as pH, temperature, total dissolved solid (TDS), and electrical conductivity on samples of sachet water from Ibadan using standard methods. They noted that pH values were higher than the recommended value by the WHO, noting that the higher pH values have an indirect effect on the body physiology. In a related study, Bomai and Waziri (2012) investigated sachet water samples in Damaturu, Yobe State. They observed that all the brands of sachet water investigated gave pH values within the set limits of 6.5-8.5 for drinking water as prescribed by NAFDAC (2001), and WHO (2006). They stated that electrical conductivity and TDS were within the required limits of 1000  $\mu\text{S}/\text{cm}$  and 500 mg/l.

Akwa Ibom State, like other states in Nigeria is faced with uneven distribution of qualitative water supply among its citizens. The widespread and long lasting shortage in many areas is as a result of rising demand, inadequate supplies of good quality drinking water. The rural people have less access to good quality water and rely on available ground water sources and use local purification methods to get clean drinking water in order to prevent health problems. There is need for this study, aimed at assessing the physical, chemical and bacteriological parameters of sachet water produced in Itu, Akwa Ibom State and comparing the results with National and International Standards in order to ascertain the suitability of the sachet water for human consumption.

## MATERIALS AND METHODS

### Study area

This study was carried out in Itu Local Government Area of Akwa Ibom State. The area is bounded in the north and north east by Odukpani in Cross River State and Arochukwu in Abia State, respectively; in the west by Ibiono Ibom and Ikono Local Government Areas, respectively; in the south and south east by Uyo and Uruan Local Government Areas, respectively. The area covers a landmass of approximately 606.10  $\text{m}^2$  with a geographical location of 5.2° north of latitude, 7.98° east of longitude and 94 meters elevation above the sea level.

### Sampling and Samples Collection

Sampling and collection of samples of sachet water were carried out from three different brands of sachet water factories in Itu Local Government Area of Akwa Ibom State. Samples were collected in February, 2014. Five samples were taken from each of the three factories. The five samples from each factory were homogenized to obtain three representative samples which were given the codes SW<sub>1</sub>, SW<sub>2</sub> and SW<sub>3</sub>. The samples were properly labeled and transported to the laboratory for the analyses.

### Determination of some Physicochemical Parameters

**Temperature:** The temperatures of the sachet water samples were read at the place of production with a thermometer and the values recorded in °C.

**The pH:** The pH values of the sachet water samples were determined with the aid of pH meter modeled ORION 2 STAR.



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**Total Dissolved Solids (TDS):** Evaporation method was adopted for TDS determination of each sample. This was done by weighing an empty beaker then filled it with known volume of the water sample and evaporating the water in oven to complete dryness. The weight of the beaker was again taken and the difference between the two weights gave the weight of the solid and TDS calculated as:

$$\text{TDS (mg/l)} = \frac{\text{Weight of solid}}{\text{Volume of sample}} \dots\dots\dots (1)$$

**Total Alkalinity:** This was done using titration method. 100 cm<sup>3</sup> of each sample was measured into conical flask. Two drops of indicator (methyl orange) were added and the solution stirred effectively. It was then titrated with 0.03M H<sub>2</sub>SO<sub>4</sub> to a faint pink colouration. The total alkalinity was calculated as:

$$\text{Total alkalinity (mg/l)} = \frac{A \times M \times 5000}{\text{Volume of sample}} \dots\dots\dots (2)$$

A = volume of standard acid used

M = molarity of standard acid used

**Turbidity:** Turbidity was determined using the turbid-meter. After the instrument was turned on, the bottle was checked and allowed to stabilize for ten minutes. Thereafter, 25 cm<sup>3</sup> of each sample was poured into the turbid-meter and reading taken accordingly.

#### Determination of Anions

**Sulphate :** Gravimetric method was used for sulphate determination. Drops of HCl were added to 100 cm<sup>3</sup> of each sample and evaporated to 50 cm<sup>3</sup>. The solution was boiled and 15 cm<sup>3</sup> boiling BaCl<sub>2</sub> solution added until a precipitate was observed. The precipitate was dried to constant weight in an oven at 103°C, cooled and then weighed. The amount of sulphate in the sample was obtained as:

$$\text{SO}_4^{2-} \text{ (mg/l)} = \frac{\text{gBaSO}_4 \times 411.5}{\text{Volume of sample}} \dots\dots\dots (3)$$

Where gBaSO<sub>4</sub> = mass in g of barium sulphate

**Phosphate:** This was done by diluting 50 cm<sup>3</sup> of each water sample with distilled water to 100 cm<sup>3</sup>. Phenolphthalein, H<sub>2</sub>S<sub>2</sub>O<sub>8</sub> was then added in their respective quantities and the solution boiled for 45 minutes. The solution was then neutralized with 0.01M NaOH to faint pink colouration. 1 cm<sup>3</sup> of vandate-molybdate was added to 25 cm<sup>3</sup> of each sample solution and absorbance taken at 470 nm. The amount of phosphate in the sample was obtained as:

$$\text{Phosphate (mg/l)} = \frac{\text{Absorbance} \times 1000 \times D^1}{\text{Volume of sample}} \dots\dots\dots (4)$$

D<sup>1</sup> = dilution factor

**Nitrate:** Nitrate was determined using the method of boric acid indicator test as described by Radojevic and Bashkin (1999). The amount of nitrate in the sample was obtained as:

$$\text{NO}_3^- \text{ (mg/l)} = \frac{28 (A-B) 1000 M}{\text{Volume of sample}} \dots\dots\dots (5)$$

A = volume of 0.02M HCl titration for sample

B = volume of 0.02M HCl titration for blank

M = molarity of HCl



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### Determination of Heavy Metals

Some heavy metals (Cu, Ni, Fe and Pb) were determined using UNICAM SOLAR 969 atomic absorption spectrophotometer (AAS). This was done by direct aspiration of water in the acetylene flame. Each water sample was aspirated into the instrument successively for the determination of each metal. The absorbance and concentrations plot of the samples (mg/l) was displayed on the screen.

### Bacterial Analysis

Methods described by APHA (2002) were used for this analysis. 9 cm<sup>3</sup> of distilled water were taken into test tubes capped and sterilized at 121°C at 15 lbs per square inch for 15 minutes. 1 cm<sup>3</sup> of each sample was taken using sterile syringe and needle and introduced into the first test tube which was serially diluted to the third test tube 1000 cm<sup>3</sup>. 1 cm<sup>3</sup> of the 1000 cm<sup>3</sup> solution was pour plated with 20 cm<sup>3</sup> of the different media. The media used were: nutrient agar (NA), for total heterotrophic bacterial count, Mac Conkey agar (MAC), for total *coliform* count, Eosin methylene blue agar (EMBA) for fecal *coliform* count and *Salmonella shigella* agar (SSA) for *Salmonella shigella* count. The plates were incubated at 37°C for 48 hours and the number of isolates noted. The following methods were used for the characteristics of the isolates: Gram stain reaction, catalase test, coagulated test, indole test, oxidase test, methylated red test, loges proskauer test, citrate test, spore strain test, and sugar fermentation test.

## RESULTS AND DISCUSSION

The results obtained from this study are as presented in Tables 1 to 4.

### Physicochemical Parameters

The levels of some physicochemical parameters of the sachet water samples are showed in Table 1. From the results, a temperature of 25.00±0.00 °C was obtained for all the brands of sachet water analyzed in this study. The pH values for the three brands SW<sub>1</sub>, SW<sub>2</sub> and SW<sub>3</sub> were 7.07±0.01, 7.25±0.01 and 7.00±0.01, respectively. These values were within the acceptable pH level for drinking water prescribed by NAFDAC and WHO. The results were in agreement with previous studies like Bomai and Waziri (2012) and Uwah et al. (2014). The values for electrical conductivity (EC) recorded in this study were 27.00±1.00, 18.23±0.25 and 59.23±0.68 µS/cm for samples SW<sub>1</sub>, SW<sub>2</sub> and SW<sub>3</sub>, respectively. These values were well below the WHO and NAFDAC prescribed standard of 1000 µS/cm for drinking water. EC indicates the amount of dissolved ions in water. The low values of EC in this study could be attributed to low concentration of dissolved ions in the water samples. Turbidity values for the three brands of samples SW<sub>1</sub>, SW<sub>2</sub> and SW<sub>3</sub> (0.67±0.01, 0.85±0.01 and 0.58±0.02) NTU, respectively fell below the recommended standard of 5.0NTU set by WHO and NAFDAC for drinking water. Turbidity is a measure of water clarity, how much the materials suspended in water decreases the passage of light through it. The low turbidity values for the water samples could be attributed to low levels of suspended or colloidal particles in the water, an indication of appropriate application of filtration technology on the side of the manufacturers. According to WHO (2011), high turbidity can seriously interfere with the efficiency of disinfection by providing protection for microorganisms in the water. As seen in Table 1, the Total Dissolved Solids (TDS) values of 2.02±0.01, 2.08±0.01 and 2.49±0.01mg/l respectively for the three brands of samples were below the WHO and NAFDAC recommended standard of 500 mg/l. The alkalinity values of 0.37±0.00, 0.10±0.02 and 0.10±0.00 mg/l, respectively for the three brands of samples obtained in this study were less than 100 mg/l prescribed by WHO and NAFDAC. According to Goel (2006), high alkalinity level in water gives unpalatable taste.

### Levels of some Anions (mg/l) in the sachet water

The levels of some anions in the sachet water analyzed in this study are presented in Table 2. Sulphate (SO<sub>4</sub><sup>2-</sup>) levels in the three brands of sachet water SW<sub>1</sub>, SW<sub>2</sub> and SW<sub>3</sub> were 14.81±0.01, 23.87±0.02 and 31.69±0.01 mg/l, respectively. These values were considerably low compared to the standard limits of 250 and 100 mg/l SO<sub>4</sub><sup>2-</sup> set by WHO and NAFDAC, respectively. The levels of phosphate in the three brands of sachet water SW<sub>1</sub>, SW<sub>2</sub> and SW<sub>3</sub> were 71.00±0.02, 66.50±0.01 and 66.50±0.00 mg/l, respectively. These values were a little higher than the standard limit of 50 mg/l PO<sub>4</sub><sup>3-</sup> in drinking water set by WHO and NAFDAC. Nitrate (NO<sub>3</sub><sup>-</sup>) levels in SW<sub>1</sub> and SW<sub>2</sub> were 0.24±0.01 and 0.08±0.02 mg/l, respectively. Nitrate was below detection limit in SW<sub>3</sub>. According to WHO (2011), nitrate can reach surface and groundwater as a result of agricultural activities.



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From this result, it can be said that the analyzed brands of sachet water are free from inorganic nitrogenous fertilizers and manures and that good treatment procedures for nitrate were adopted in the water factories.

#### Levels of some heavy metals (mg/l) in the sachet water

The levels of some heavy metals analyzed in this study are presented in Table 3. Copper (Cu) levels in all the water samples in this study were less than 0.001mg/l. The standard limits of copper in drinking water set by WHO and NAFDAC are 0.5 and 1.0 mg/l Cu, respectively. Iron (Fe) levels in the three respective brands of sachet water were  $1.79\pm0.02$ ,  $0.45\pm0.01$  and  $1.63\pm0.01$  mg/l Fe. The values of  $1.79\pm0.02$  and  $1.63\pm0.01$  mg/l Fe recorded in samples SW<sub>2</sub> and SW<sub>3</sub> respectively, were a little higher than 1.0 and 0.3 mg/l Fe in drinking water set by WHO and NAFDAC in that order. It has been reported that deficiency of iron in human causes anemia, but high dosage cause undesirable taste and gastrointestinal irritation (Rao, 2008). According to WHO (2006), high level of iron in drinking water is as a result of iron coagulant used in treatment processes or from corrosion of steel and cast iron pipes during water distribution. Nickel (Ni) levels of  $0.08\pm0.01$ ,  $< 0.001$  and  $0.17\pm0.00$  mg/l in the three brands were within the standard limits of 0.07 and 0.02 mg/l Ni in drinking water set by WHO and NAFDAC. WHO (2011) links the source of Ni in drinking water to materials used for taps and fittings which could raise the concentration of Ni up to 1.0 mg/l. Lead (Pb) level in sample SW<sub>1</sub> was less than 0.001 mg/l compared to the acceptable standard limit of 0.01mg/l Pb in drinking water set by both WHO and NAFDAC. Values of  $0.16\pm0.02$  and  $0.30\pm0.01$  mg/l Pb obtained in SW<sub>2</sub> and SW<sub>3</sub> respectively were a little higher than the standard limit. High doses of Pb had been identified as a cumulative general metabolic poison, with symptoms to include among others: tiredness, lassitude, anemia, discomfort and instability. WHO (2011) attributes the source of Pb in drinking water to lead pipes used for plumbing connections.

#### Bacterial contents in the sachet water

Bacteriological evaluation gave no trace of *coliform* or bacterial count in all the three brands of sachet water analyzed in this study. These results are against those of Mohammed et al. (2012) which revealed that 55% of the brands samples analyzed had fecal *coliform*, 25% had *Pseudomonas aeruginosa*, 15% had *Salmonella typhi* while 5% had *Escherichia coli* (*E. coli*) which they attributed to the fact that the water were either not treated or produced under unhygienic condition. The results obtained in this study were also not in agreement with those of Alli et al. (2011) who noted that 73.3% of the sachet water analyzed had growth of pathogenic organisms in the first batch, while 66.6% had growth in the second batch and that the isolates were identified to be *Klebsilla spp.*, *Serrata spp.*, *Chromobacterium spp.*, *Pseudomonas aeruginosa* and *Proteus spp.*, and that *Klebsilla spp.*, was the most dominant and the mean total heterotrophic bacteria plate count (HPC) per milliliter ranged from  $0.00 - 6.0\times10^2$  CFU/cm<sup>3</sup> at 22°C in the first batch and  $0.00-7.0 \times 10^2$  CFU/cm<sup>3</sup> at 37°C in the second batch. The absence of *E. coli* and other fecal indicators in the sachet water samples analyzed in this study shows that the water are free from fecal contamination, thereby suggesting good and hygienic operative conditions as required.

#### CONCLUSION

Based on the analyses and results, it can be concluded that consumption of the three brands of sachet water investigated for various parameters in this study may not pose possible health hazards at the time of the study. This is because the results showed that the levels of all the parameters investigated were either below or within the standard limits in drinking water set by WHO and NAFDAC, except for PO<sub>4</sub><sup>3-</sup>, which levels were slightly higher than the standard limit of 50 mg/l PO<sub>4</sub><sup>3-</sup> in drinking water. In addition, the results revealed good water quality in terms of bacteriological evaluation as no trace of *coliform* or bacterial contamination was recorded in any of the brands.

Periodical monitoring of the levels of the studied parameters of these and other sachet water from the study area and its environ is strongly recommended in order to ascertain the suitability or otherwise of such water for human consumption.



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**Table 1: Levels of Physicochemical parameters of the sachet water from Itu**

Parameters	Samples			Standards	
	Sw <sub>1</sub>	Sw <sub>2</sub>	Sw <sub>3</sub>	WHO	NAFDAC
Temp. (°C)	25.00±0.00	25.00±0.00	25.00±0.00	-	-
pH	7.07±0.01	7.25±0.01	7.00±0.01	7.0-8.9	6.5-8.5
EC (µS/cm)	27.00±1.00	18.23±0.25	59.23±0.68	1000	1000
Turbidity (NTU)	0.67±0.01	0.85±0.01	0.58±0.02	5.0	5.0
TDS (mg/l)	2.02±0.01	2.08±0.01	2.49±0.01	500	500
Alkalinity (mg/l)	0.37±0.00	0.10±0.02	0.10±0.00	100	100

Results are mean of triplicate determinations ±S.D

**Table 2: Levels of some Anions (mg/l) in the sachet water from Itu**

Anions	Samples			Standards	
	Sw <sub>1</sub>	Sw <sub>2</sub>	Sw <sub>3</sub>	WHO	NAFDAC
SO <sub>4</sub> <sup>2-</sup>	14.81±0.01	23.87±0.02	31.69±0.01	250	100
PO <sub>4</sub> <sup>3-</sup>	71.00±0.02	66.50±0.01	66.50±0.00	50	50
NO <sub>3</sub> <sup>-</sup>	0.24±0.01	0.08±0.02	BDL	10	10

Results are mean of triplicate determinations ±S.D; BDL = below detection limit

**Table 3: Levels of some Heavy metals (mg/l) in the sachet water from Itu**

Heavy metals	Samples			Standards	
	Sw <sub>1</sub>	Sw <sub>2</sub>	Sw <sub>3</sub>	WHO	NAFDAC
Cu	< 0.001	< 0.001	< 0.001	0.5	1.0
Fe	1.79±0.02	0.45±0.01	1.63±0.01	1.0	0.3
Ni	0.08±0.01	< 0.001	0.17±0.00	0.07	0.02
Pb	< 0.001	0.16±0.02	0.30±0.01	0.01	0.01

Results are mean of triplicate determinations ±S.D; < = Less than

**Table 4: Level of Bacterial contents (CFU/cm<sup>3</sup>) in sachet water from Itu**

Samples	Bacterial contents		
	THBC	TCC	TSSC
Sw <sub>1</sub>	1.2x10 <sup>-4</sup>	0	0
Sw <sub>2</sub>	2.0x10 <sup>-4</sup>	0	0
Sw <sub>3</sub>	1.8x10 <sup>-4</sup>	0	0
WHO	100	<10	0
NAFDAC	100	<10	0

< = Less than; THBC = Total heterotrophic bacterial count; TCC =Total *coliform* count; TSSC = Total *Salmonella shigella* count



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